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Comparison of fish and amphibian communities in a floodplain system of the rivers Traisen and Danube westwards of Vienna

by
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Abstract: Within the framework of a river restauration concept at the river Traisen a simultaneous investigation of fish and amphibian coenoses was performed. Due to human impacts the ecological integrity of many backwater systems is low, evaluating both vertebrate groups is a possible way of a deficit analysis in lentic ecosystems. The results are compared to recent publications, the importance of habitat variability for species richness and co-existence of both groups is stressed and proved.
Keywords: Amphibia, Pisces, floodplain, Danube, Traisen, backwaters, inundation area, Austria, river restauration

Introduction

Between 1996 and 1998 backwaters of the River Traisen and the River Danube were investigated within the river restauration concept GBK (Gewässerbetreuungskonzept) Traisen (Eberstaller *et al.* 1999). The GBK Traisen, influencing the section from the city of Wilhelmsburg to the mouth into the Danube, was a water resources management concept to protect human settlements from floods and to improve the ecological integrity of the observed systems. The entire region was investigated for the first time at a high and complex ecological level. This paper should further to our existing faunistical knowledge, as well as contribute to a better understanding of possible co-existence between fish and amphibians.

GBK concepts show interdisciplinarity on a high level, we had the possibility to investigate fish- and amphibian communities simultaneously and from a similar view. Most publications, dealing with the co-existence of these two vertebrate groups, stress results of selected taxa, whereas the framework of a GBK permits simultaneous and equally weighted field investigations of fish and amphibians. In most publications studying both vertebrate groups (Müller 1968, Flindt & Hemmer 1969, Broggi 1975, Filoda 1981, Clausnitzer 1983a, b, Gebhardt 1985, Hehmann & Zucchi 1985, Dolmen 1987, Bradford 1989, Amtkjaer 1988, Holmen & Wederkinch 1988, Breuer 1992, Banks *et al.* 1993, Sound & Veith 1994), especially fish data refer mostly to only few selected taxa. Pintar & Spolwind (1998) tried to compile a synopsis of fish and amphibian data in a floodplain area of the Danube near Vienna, where several backwater types could be distinguished, and they stressed the importance of vertical structures and the availability of inundation areas during spawning periods of amphibians for a possible co-existence of both groups.

Because of their specific demands to different habitat types during their life cycle amphibians have an important indicator function in evaluating aquatic systems and their semiterrestrial and terrestrial surroundings (Blab 1978, 1986, Blab *et al.* 1984, Tiedemann 1990). In Central Europe all amphibian species show severe population reductions and suffer loss of habitats. One of the most important reasons for the endangerment of amphibians is their strong reliance on aquatic as well as to terrestrial habitats. Reasons for population declines are intensive agri-

culture as well as human influence in aquatic systems. All Austrian amphibian species are in the "Red List of Endangered Species" (Grillitsch *et al.* 1983).

Many Austrian fish species are endangered, the present stock development is rather deplorable. About 70% of the Austrian autochthonous fish fauna is on the "Red List of Endangered Species" (Spindler *et al.* 1997). The major threats to the survival of the indigenous fish fauna are human-caused changes in their habitats, i.e. the water bodies. The main factor for the deplorable situation seems to be the large number of measures of hydraulic engineering and diverse use of water for economical and recreational purposes. Many fish species are extremely sensitive to environmental impacts and are increasingly used as bioindicators (Spindler *et al.* 1997). Their presence and absence in water bodies as well as community and population parameters of selected species provide information on the ecological status of aquatic systems.

Co-existence of amphibian and fish coenoses depends to a high degree on the availability of numerous habitat types and possible habitat segregation (e.g. flooded, shallow areas for amphibian spawning) to avoid interspecific predator–prey interactions (Clausnitzer 1983a, b, Pintar & Spolwind 1998, Spolwind & Pintar 1997a, b). This fact implicates that a simultaneous screening of both groups and an according analysis (mostly multivariate) is a sound way for evaluating the status of an aquatic or semiaquatic system.

In this investigation area two significantly different alluvial subsystems are characterised: the upstream Traisen region is a heavily regulated system with degraded forests; water bodies are strictly limited. The downstream region, the Danube–Traisen system, is also regulated, but shows high ground water level with large riverine forests. Both systems differ in density, structure and biocoenotic characterisation of their backwaters (Waidbacher *et al.*1998, Schludermann *et al.* 1998).

Materials and method

Investigation area

The studied region is situated in the inundation area of a potential centennial spate occurrence (HQ100) at the Traisen from Wilhelmsburg to the mouth into the Danube. In the area downstream of the town of Traismauer inundation areas of the Traisen and the Danube overlap, and characteristics of backwater types differ in stretches of the Traisen. 85 different backwaters were studied, 44 of them are situated in the heavily human-influenced area upstream of Traismauer to Wilhelmsburg, 41 backwaters were found in the more undisturbed region downstream of Traismauer. Characterisation of different types of waterbodies followed Gepp (1985) and Pintar & Spolwind (1998).

The Traisen can be characterised as follows: a middle stretch river with stream order 6 (Horton 1945, Strahler 1957) with pluvio-nivale discharge in the transit of hyporhitral to epipotamal. Historically various temporary and permanent backwaters were found (Schludermann 1998); today the Traisen is a heavily modified river, characterised by regulation and residual flow problems. Due to a historical flood event (HQ100) many backwater systems showed impacts as altered morphology and inputs of drifted fish species.

The following types were distinguished:

Temporary backwaters: different types of systems that are only temporarily filled with water, backwaters differ in size, choriotope, vegetation and shade.

Permanent backwaters: due to their different hydrology we distinguish:

— backwaters of first order: backwaters that are permanently connected to a flowing water system, in this case the river Traisen.

— backwaters of second order: more isolated backwaters that are in connection with a flow water system at a higher mean water level.

— backwaters of third order: isolated systems that are only inundated during flood events.
— flowing backwaters: small streams in the Traisen–area
— artificial waterbodies: fish ponds.

The backwaters were investigated with different methods during 1997 to obtain a complete set of fish and amphibian coenoses. Fish were mainly detected by electrofishing. Fish show characteristic galvanotaxis in an electric field (Cowx & Lamarque 1990), we used 1.5 or 2.5 KW aggregates (DC) with 300–600 voltage. Amphibian populations were either evaluated by counting spawning clutches (mainly *Rana dalmatina*) or by searching for larvae or metamorphosed juveniles (Pintar & Straka 1990). Larval occurrence was identified by standardised catches with a hoop net.

Although we tried a similar and simultaneous field analysis of fish and amphibian coenoses, field survey of both groups was achived by different methods. Fish coenoses can be quantified by electrofishing, whereas amphibians were quantified only in the case of *Rana dalmatina*. Therefore, for data analysis a hierarchical cluster analysis was applied after Ward, we used single habitats as cases and binary species records of fish and amphibians as variables. To determine distance between cases, Squared Euclidean

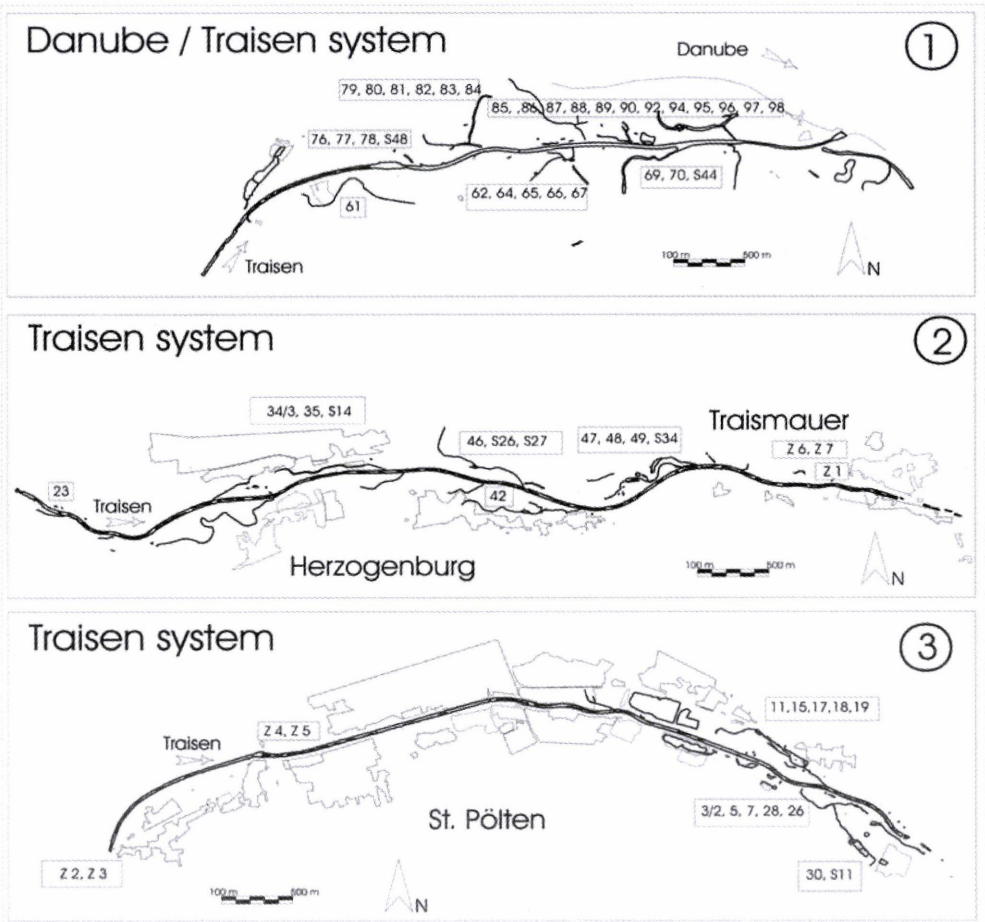

Fig.1. The investigation area: Numbers refer to backwater characterisation and are cited in the text

Distance was applied. In our case cluster analysis after Ward provides homogenous cluster results (Bortz 1993, Brosius 1995, Ward 1963), and this statistical procedure was used in similar studies (Pintar & Spolwind 1998, Kummer *et al.* 1999). Results of the cluster analysis are presented as tables, segregation into clusters and subclusters was performed by interpretation of dendrogams not shown in this paper.

Results

The comparison of the two alluvial systems reveals that the Danube–Traisen and the Traisen region differ in various parameters. The Traisen region is defined by its larger extent, and due to massive human impacts (settlements, critical groundwater situation) the total number of backwaters, the detected spawning places of amphibians as well as suitable habitats of fish are lower, than in the compared Traisen–Danube area.

Table 1. Characterising area – Parameters for the 2 floodplain systems, the Traisen and the Traisen–Danube area. The ecologically usable area is defined as total area minus settlement used area.

Parameter	Traisen system	Danube–Traisen system
Total area (m^2)	11.546.825	6.184.253
Traisen River length within the system (km)	30.6	8.1
Ecologically usable area (m^2)	2.180.512	6.032.512
Total number of backwaters	41	44
Number of Amphibian spawning habitats	26	34
Number of relevant fish habitats	15	20
Number of fish habitats with stable coenoseses	5	10

We defined the "ecologically suitable area" as the total area of a subsystem minus areas influenced by massive human impact (settlements, roads). Although the Traisen subsystem has a much larger total area, the amount of the ecologically usable surface is significantly smaller, than in the compared Danube–Traisen Subsystem. Figure 2 shows differences in size-distribution of backwater habitats in the two distinguished subsystems. Habitats with an extent larger than 5000 m^2 are mainly restricted to the Danube–Traisen area. Small, mainly shadowed, filled in backwaters are dominant in both subsystems. The occurrence of larger habitats in the Danube–Traisen region is reflected by biocoenotic parameters indicating stable fish habitats.

Recorded fish and amphibian species

During our field investigations we found 30 fish species in the backwater systems, of these only a small portion can form vital populations. We found 13 amphibian species in the entire system, *Rana lessonae* and *Rana esculenta* were combined as Greenfrog-complex. The following figure shows the distribution of the detected fish species in the two different sampling areas of the region. The Danube–Traisen area with its heterogeneous backwater characteristics shows higher species numbers and abundances. Most records of rheophilic species can be explained through drift during flood events during summer 1997; only few of the studied running water habitats provide suitable environments for rheophilic species.

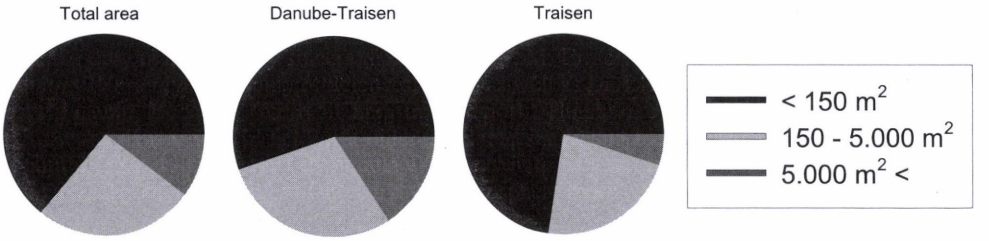

Fig. 2. Distribution of different size-classes in the Traisen–Danube and the Traisen system

Table 2. List of detected fish species. Fish species can be divided into several ecological groups due to Schiemer & Waidbacher (1992, 1998). RA = Rheophilic A, RB = Rheophilic B, EU = Eurytopic, LI = Limnophilic

Name	Ecological group	Used abbreviation	Name	Ecological group	Used abbreviation
Salmo trutta forma *fario*	RA	Stff	*Esox lucius*	EU	Eslu
Oncorhynchus mykiss	RA	Onmy	*Alburnus alburnus*	EU	Alal
Thymallus thymallus	RA	Thth	*Blicca björkna*	EU	Blbj
Chondrostoma nasus	RA	Chna	*Abramis brama*	EU	Abbr
Barbus barbus	RA	Bb	*Carassius auratus gibelio*	EU	Caug
Leuciscus leuciscus	RA	Lele	*Perca fluviatilis*	EU	Pefl
Leuciscus cephalus	RA	Lece	*Stizostedion lucioperca*	EU	Stlu
Phoxinus phoxinus	RA	Phph	*Proterorhinus marmoratus*	EU	Prma
Gobio albipinnatus	RA	Ga	*Cyprinus carpio*	EU	Cyca
Barbatula barbatula	RA	Baba	*Scardinius erythrophthalmus*	LI	Scer
Leuciscus idus	RB	Leid	*Rhodeus sericeus amarus*	LI	Rosam
Aspius aspius	RB	Asas	*Carassius carassisus*	LI	Caca
Gobio gobio	RB	Gogo	*Tinca tinca*	LI	Titi
Anguilla anguilla	EX	Anan	*Misgurnus fossilis*	LI	Mifo
Rutilus rutilus	EU	Ruru	*Gasterosteus aculeatus*	LI	Gaac

Table 3. List of investigated Amphibian species.

Name	Used abbreviation
Triturus dobrogicus	TD
Triturus vulgaris	TV
Salamandra salamandra	SS
Bombina bombina	Bbo
Pelobates fuscus	Pf
Bufo bufo	Bbu
Bufo viridis	Bv
Hyla arborea	Ha
Rana dalmatina	Rd
Rana temporaria	Rt
Rana ridibunda	Rr
Rana lessonae	GF
Rana kl. *esculenta*	GF

Fish and amphibian coenoses: characterizing parameters

Figure 3 shows the distribution of the detected fish species in the Danube–Traisen and the Traisen system. Due to its higher variability in backwater types, the Danube–Traisen system shows higher species numbers. We distinguished stable fish coenoses (species assemblages capable of reproducing themselves) and coenoses that are formed by a massive flood event that occurred a few weeks before sampling (Fig. 4). The stable coenoses showed a characteristic population structure, backwaters with stable coenoses were rare and limited mainly to larger backwaters in the Danube–Traisen system. Small backwaters usually showed no, or untypical fish assemblages and were found in the Traisen as well as in the Danube–Traisen area. Figure 5 shows the records of the 11 amphibian

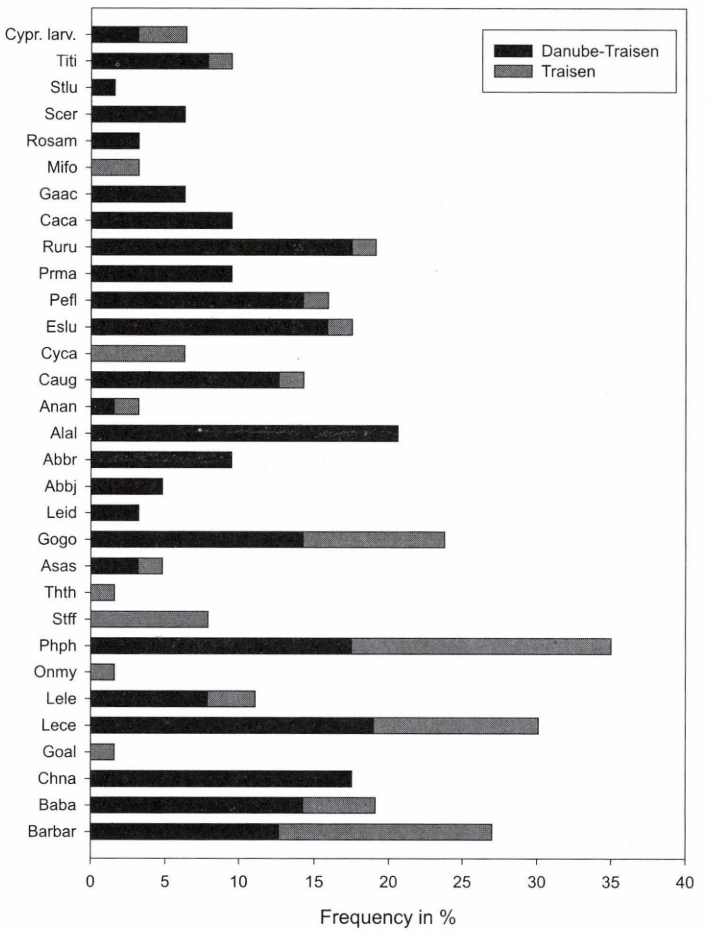

Fig. 3. Distribution of recorded fish species in the Traisen and Danube–Traisen region. 63 backwaterswere investigated.Abbreviations are shown in Tab. 2; Cyprinid larvae (Cypr. larv.)are indeterminable larvae of Cyprinid fishes

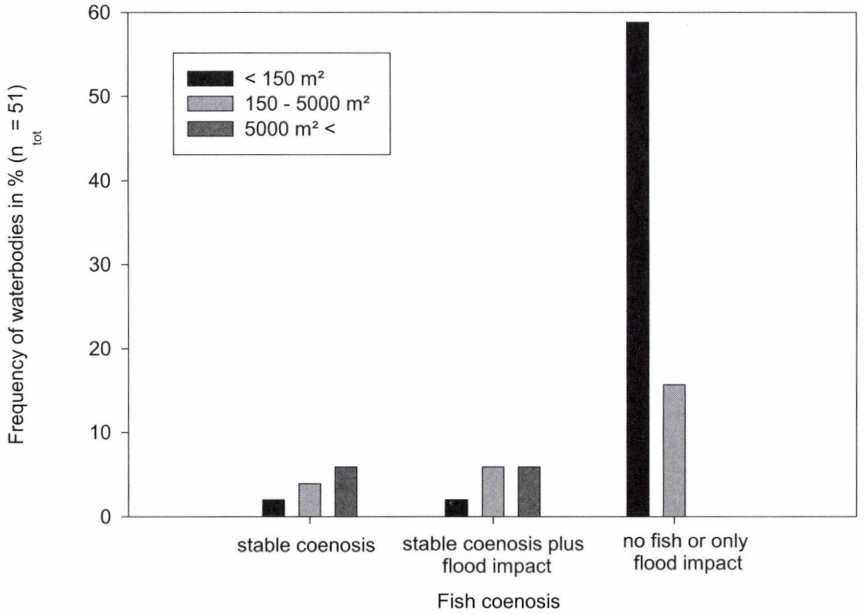

Fig 4. Distribution of different fish community structures depending on the size of habitats. Only stagnant backwaters are taken into account (n = 51)

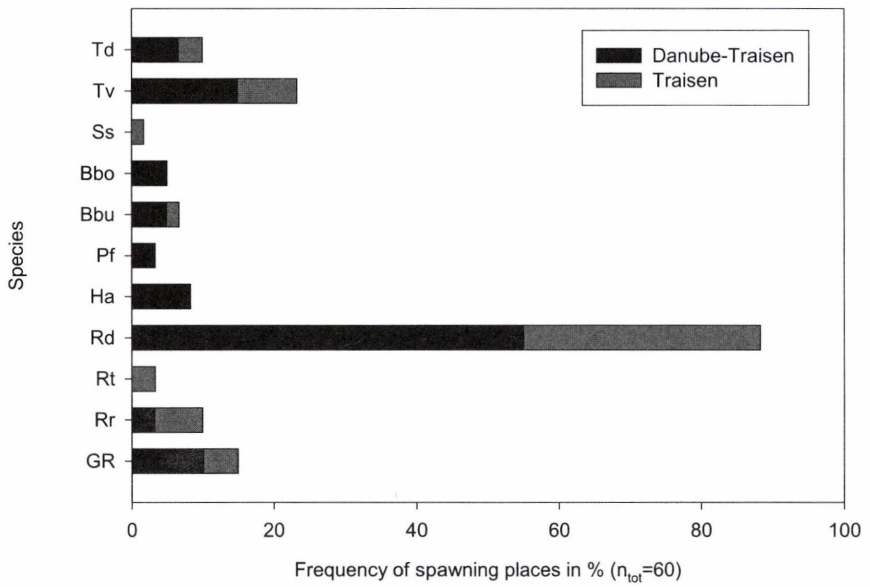

Fig. 5. Distribution of recorded Amphibian species in the Traisen and Danube–Traisen region

species, or pooled taxa (Greenfrogs) in the Traisen and Danube–Traisen system. Compared to the results of the fish coenoses, amphibians show higher species numbers and abundances in the Danube–Traisen region, whereas *Salamandra salamandra* and *Rana temporaria* are restricted to a few spots in the Traisen areas. In the entire system 60 habitats were classified as amphibian spawning places.

Fig. 6 shows the distribution of proven spawning records of amphibians in the two study areas. Habitats with only one species (mainly *Rana dalmatina*) were dominant in both subsystems, whereas higher species numbers were mainly restricted to the downstream region with its diverse backwater distribution. Areas characterised by higher species numbers are spatially unevenly distributed: they are mostly located in the Danube–Traisen area.

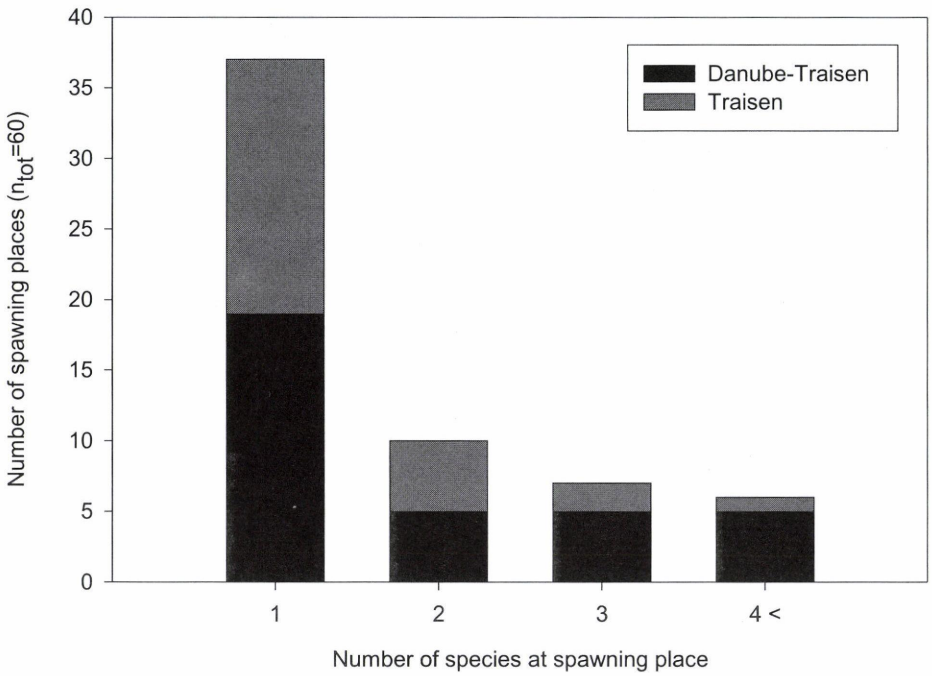

Fig. 6. Frequency of spawning places with different amphibian species records

Cluster analysis of fish and amphibian data

The next step in data investigation was the performance of a hierarchical cluster analysis (after Ward), we used binary data files to investigate fish and amphibian communities in separate ways: In the analysis of fish data only backwater systems with stable fish coenoses were considered, the cluster can be separated in 2 major groups, one group (cluster 1–3) consists of habitats with low species numbers, the second group (cluster 4) includes intact, mostly larger habitats with higher species numbers.

Table 4. Cluster analysis (Ward) of stagnant back water types with stable fish coenoses. Split numbers show mesohabitats within one backwater system.

Cluster	Backwaters	Characterising species	Type
1.1	46, 7, 35	*C. carpio*	Fish ponds
1.2	28, 5	*M. fossils*	Backwater 3. order
2.1	83, 94	*P. fluviatilis, R. rutilus., A. alburnus*	Backwater 3. order
2.2	62, 89	*E. lucius, R. rutilus*	Backwater 3. order
2.3	92/1	*E. lucius, R. rutilus, T. tinca, B. bjoerkna*	Backwater 3. order
3.1	86, 88, 64	*C. a. gibelio, C. carassius, R. rutilus*	Backwater 3. order
3.2	87, 90	*P. fluviatilis, G. aculeatus, P. marmoratus, C. auratus gibelio, A. alburnus, A. brama*	Backwater 3. order
4.1	84, 85	*T. tinca, C. carassius, S. erythrophthalmus, E. lucius, R. rutilus, A. alburnus, P. marmoratus, P. fluviatilis, A. brama*	Backwater 2. order
4.2	70	*L. idus, L. cephalus, E. lucius, R. rutilus, A. alburnus, P. marmoratus, P. fluviatilis, A. brama, B. bjoerkna,*	Backwater 1. order
4.3	98	*E. lucius, R. rutilus, A. alburnus, A,. brama, P. fluviatilis, P. marmoratus, T. tinca., S. erythrophthalmus*	Backwater 2. order

The result of the hierarchical cluster analysis of fish data of stagnant backwaters shows a segregation due to typology of habitats and due to their position in the investigated area. Backwaters of third order show mostly low species numbers, eurytopic and limnophilic species dominate. Both species numbers and rate of rheophilic elements increase in more dynamic backwater types (systems of second and first order, cluster 4). Relevant habitats in the Traisen region are rare (Nr. 28 and 5) and show limnophilic fish coenoseses, where *M. fossilis* is dominant. Habitats with higher species numbers are restricted to the Danube–Traisen region.

Flowing Backwaters

This separated cluster analysis includes all investigated flowing systems with representative fish coenoses. We distinguished three clusters, cluster one is defined through low species number and eutrophication; cluster 2 and 3 are backwater systems with different human impact. Subclusters 2.2 and 3 show well structured, typical flow water conditions. Clustering flowing water systems shows a segregation between human influenced systems (Nr. 61, 42) with high eutrophication and fluctuating water levels and more natural habitats (mostly cluster 3, Nr. 30) with its significantly higher species numbers.

Table 5. Cluster analysis (Ward) of flowing backwater types with stable fish coenoses. Split numbers show mesohabitats within one backwater system.

Cluster	Backwaters	Characterising species	Type
1.1	42, 61	*P. phoxinus, B. barbatula, L. cephalus, P. fluviatilis*	Low flow section of a small backwaters, highly eutrophicated backwater
2.1	34_3	*S. t.f. fario, B. barbus, L. cephalus, P. phoxinus, G. gobio, R. rutilus, C. a. gibelio*	Human influenced urban backwater section
2.2	48	*S. t.f.fario, L. cephalus, P. phoxinus, B. barbatula, G. gobio,*	Small, shadowed, non affected stream
3	30	*S. t. f. fario, O. mykiss, P. phoxinus, B. barbatula, G. gobio, A. anguilla, P. fluviatils*	Heterogeneous non affected flowing system

Corresponding to fish data we clustered amphibian species records with a hierarchical cluster analysis after Ward. The result is a diversion into 4 clusters, we used the backwater type and presence versus absence of fish communities as descriptive factors in Table 6. Clustering results seem to be explained best by backwater typology and influencing fish communities in different systems. Fish presence in unstructured systems can lead to the exclusion of heterogeneous amphibian communities; only well structured habitats (present in the Danube–Traisen system) allow real coexistence of diverse fish and amphibian communities. A synopsis of the results of fish and amphibian clusters shows the impact of backwater typology and biocoenotic influences on the distribution of the two vertebrate groups. Fish are significantly grouped in habitats of similar hydrology/typology, whereas the distribution of amphibians is strongly influenced by typology as well as habitat configuration and the presence/absence of fish. Sensitive species as *H. arborea* are only present in the Danube–Traisen region; habitats without fish or with extensive, shallow inundation areas are strongly preferred. The cluster with the highest case number is cluster 3 with dominance of brown frogs. Especially the common species, *R. dalmatina,* shows highly frequent occurrence in nearly all backwater types and is often found as the only remaining species. In combination with *B. bufo* habitats with high fish biomass are colonised.

Table 6. Cluster analysis (Ward) of flowing backwater types with stable fish coenoses. Split numbers show mesohabitats within one backwater system.

Cluster	Backwater	Characterising species	Type	Fish	Comments
1.1	Z6, z7	Ha	Temporary backwaters	Absent	Isolated pioneer habitats
1.2	30	Ss	Flowing backwater	Absent	Heterogeneous flowing system
1.3	Z4, z5	Rr	Temporary backwaters	Absent	Temporary inundation areas of the Traisen
2.1	78, 97/1, 5/1	Rd, Greenfrogs	Warm, temporary backwaters	Absent	Shallow areas of backwaters
2.2	35, 7, 3/2	Greenfrogs	Fish ponds, inundated areas	Present	Warm, nonstructured areas
2.3 - 2.5	92/1, 98/1, 96	Highest species numbers	Permanent systems	Present/absent (3. order)	Warm, well structured areas
3.1	70/3, 84	Rd, Bb	Backwaters 1/3. order	Present	Large, deep systems
3.2	S48, z1, z2, 11, S34, S44, S26, S27, S11, S14, 98, 98/2, 95, 97, 89, 92/2, 80, 81, 77, 79, 69, 76, 62a; 65, 67, 49, 61, 46, 47 23, 26, 15, 17	Rd	Temporary systems, backwaters 3. order	Present/absent	Heterogeneous group of backwaters e.g. shadowed temporary systems, backwaters with high fish biomass
3.3	Z3	Rt	Temporary backwaters	Absent	Small, warm backwater
4.1, 4.2	28, 94, 5, 64	Rd, Rr, Tv, (Tc)	Backwaters 2. / 3. order	Present	Warm backwaters, high macrophyte biomass
4.3	62, 86, 87	Rd, Tv, Tc, (Ha)	Permanent backwaters 3. orders	Absent/instable	Small-medium sized backwaters
4.4	82, 90	Rd, Ha, Tv	Permanent backwaters 3. order	Present/absent backwaters	Medium sized
4.5	18, 66, 19, 11	Rd, Tv	Permanent backwaters 3. order	Absent/instable backwaters	Non structured, shadowed

Discussion

Intensive investigations on the impact of fish on amphibians were performed by Breuer (1992). Spolwind & Pintar (1997a, b) and Pintar & Spolwind (1998) show results of comparable Danubian alluvial systems. Fish predation seems to be an important factor for the distribution of several amphibian species (mainly brown frogs, *Triturus vulgaris, Hyla arborea*) (Breuer 1992, Clausnitzer 1983a, b, Fog 1988, Pintar & Spolwind 1998, Spolwind & Pintar 1997a, b), while other species, like *Bufo bufo,* are not negatively influenced by fish predation (Gössling *et al.* 1981). In his field experiments Breuer (1992) showed that only *Leuciscus cephalus* and *Perca fluviatilis* feed on *Bufo* larvae at higher rates, similar results are published by Clausnitzer (1983a, b), Filoda (1981), Hehmann & Zucchi (1985), and Kwet (1996). Clausnitzer (1983a, b) and Pintar & Spolwind (1998) point out the importance of structured habitats with shallow areas that cannot be reached easily by adult fish individuals.

In our study fish and amphibians were investigated on a holistic level because co-existence and interspecific interactions between these two groups can be used to evaluate the status of complex aquatic systems and can function as an indicator of habitat diversity (Pintar & Spolwind 1998, Spolwind 1999). Our results clearly show that high abundance of fish does not necessarily limit the occurrence of amphibians. In the riverine forests of the Danube–Traisen area, comparatively high density of suitable spawning sites lead to higher densities of individuals and species of both amphibians and fish. Fish cluster 4.3 (stagnant backwaters) and amphibian cluster 2.4, representing a large backwater system near the Danube show high fish and amphibian species numbers and also high biomass of both groups. This backwater system is a good example of habitat diversion due to lateral and vertical segregation.

The rather devastated riverine forest area of the Traisen shows nearly no stable fish-coenoses in the standing water bodies, and rather limited numbers of a few ubiquitous amphibian species. Only fish cluster 1.2 (stagnant backwaters) with its limnophilic fish association shows a stable, balanced fish coenoses. The impact of species as *M. fossilis* on amphibians is regarded as low (Pintar & Spolwind 1998), comparatively high species numbers of amphibians do coexist in here (amphibian cluster 4). This does not mean that there are no negative effects of fish on the amphibian coenoses in the Traisen–Danube area. But the more balanced ecosystem, even if only in a seminatural situation, allows co-existence of the two animal-groups on a higher unit of scale. The main reason for this should be the higher availability of aquatic habitats, the less influenced total area and the higher degree of structural richness e.g. temporary shallow waters and dense vegetation that allow the described co-existence (see also fish cluster 2.3 in stagnant habitats in comparison with amphibian cluster 2.5).

The area of the Traisen system, a heavily human-influenced section, with nearly no habitat diversity, showed the occurrence of generalist amphibian species (*R. dalmatina,* amphibian cluster 3.2) or a lack of amphibian populations. The lack of vertically structured habitats leads to an exclusion of fish and amphibians in most habitats in this area. The Traisen region with its mainly small, shadowed backwaters or running water systems (fish cluster 2 and 3 in flow water systems) can be opposed to the Danube–Traisen part with its comparatively low human influence and various backwater types. Co-existence of stable coenoses of both groups could only be found here. Species richness of fish communities is an excellent indicator of hydrological dynamics here, fish cluster 4 represents connected or partly connected systems, fish species numbers increase especially significantly.

In the entire system, backwaters smaller than 150 m^2 are dominant, the biggest part of them is shadowed and exhibit a temporary character. Larger systems with a permanent character and adequate shallow water areas are limited to the Traisen–Danube system. Only this area has in our days the potential for a co-existence of both vertebrate groups and can, at least partly be classified as a system with approximately better ecological integrity. The concurrent analysis of fish and amphibia data provides a better understanding of the functionality of ecological systems. We believe that an analysis of both vertebrate groups as well as an analysis of presence/absence co-existence of the two compared groups is a suitable way to evaluate backwater systems.

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